IPIC 2016
3rd International Physical Internet Conference
June 29-July 1, 2016 I Atlanta, GA USA

SmartBox – an Austrian PI solution leading to small loads mobility 4.0

Kapplmüller Harald[1]; Hans-Christian Graf[1];
Sophie-Therese Hoertenhuber,[1]
Rainer Widmann[2], Burkhard Stadlmann[2]
1. University of Applied Sciences Upper Austria - Logistikum Steyr
2. University of Applied Sciences Upper Austria
School of Engineering and Environmental Sciences, Wels
Corresponding author: harald.kapplmueller@fh-steyr.at

Abstract: *Driven by the growing e-commerce sector the market for small loads like parcels is not characterized by sustainability in Europe. Constantly rising shipment volumes, increasing customer service awareness and growing demands for deliveries in best shipping quality and time accuracy drive existing distribution service systems into inefficiencies like multiple deliveries and underutilized truck capacities. After the investigation of actual systems and conditions on the Austrian CEP market a new PI-based business model is proposed to lead to a sustainable solution for a new and holistically optimized CEP market system. Key elements of the solution are an intelligent communication system (the "Hypersystem") and necessary standardizations to make asset sharing possible. To support the environment friendly re-use of unit loads the "SmartBox" was developed as intelligent carrier for all stakeholders in an open distribution market as well as the "SmartTerminal" as effective decoupling point in the first and last mile of the delivery process.*

Considering the ideas of the Physical Internet (PI) this paper summarizes researched and engineered core elements of small load containers, the SmartBoxes, being essential for the implementation of sustainable future small loads distribution systems.

Keywords: *Physical Internet, Realization of the Physical Internet, SmartBox, PI container, core elements of small loads mobility*

1 Introduction

1.1 Present CEP market conditions

The market for CEP service and freight transport is very complex in Europe and in Austria specifically. It is characterized by changing mobility needs of customers and by a variety of more or less innovative solutions to meet the e-commerce-driven customer needs. Home deliveries grow analogous to increasing shopping habits on the Internet. Altered mobility, demographic change and increasing employment justify the increasing business in e-commerce, but lead to a so-called "online shopping paradox": It increases the number of online shoppers; however, the possibility for a personal reception of deliveries decreases. The consequences are more often and expensive delivery attempts, or the client takes the efforts of a self-pickup (Schnetlitz/Lienbacher/ Waldegg-Lindl B./Waldegg-Lindl M. 2013). The market of parcel deliveries is also influenced by other developments, e.g., delivery services are increasingly restricted by access restrictions in urban areas (Graf/Kapplmüller 2015). Pedestrian areas are extended constantly and there is a steadily regulation of access times. Furthermore, in cases where the entrance of cities is limited to electric vehicles is growing. E-mobility as a whole plays a growing role in the last mile. Moreover, the market of CEP services is characterized by tough competition regarding the price as well as costs play a major role (Bogdanski 2014). Fierce competition leads to elimination of unprofitable actors and sets remaining players under pressure. This leads to a sharp differentiation of the market players creates a situation in which the individual CEP service provider to internally work efficiently, but there is no overall optimum in the market.

2 The SmartBox approach

The SmartBox concept tries to solve the problem based on the idea of the Physical Internet which was co-funded by the Austrian Research Promotion Agency (FFG). An open asset sharing network is foreseen to supersede the current distribution system of parcels efficiently and sustainably by the incorporation of a standardized reusable container (the "SmartBox") and local drop points (the "SmartTerminals") (Graf and Kapplmüller 2015).

The definition and design of a new business model for open and shared transport partnerships including its functional levels lead to the design of a coordinating Hypersystem. The Hypersystem has the function to synchronize and optimize the deliveries in general and split the benefits to the business partners in a transparent and fair way. Standardized information flows enable potential system partners to increase bundling of volumes and vehicle utilization. Due to the definition of fair algorithms and business rules, the Hypersystem acts as a master instance to ensure access for all qualified actors to relevant information.

To avoid typical friction losses like unsuccessful delivery attempts on the last mile in the B2C deliveries, the SmartTerminal was co-developed within the overall concept. The SmartTerminal serves as decoupling point between service providers and final customer; furthermore, it permits the secure transfer of deliveries without the necessary presence of the end customer. Thereby the SmartTerminal serves as a local micro depot and manages to bundle deliveries of a certain distribution area. By the involvement of private actors (crowd delivery function) extended delivery services to the door of the final receiver can be added as Last-Last-Mile services.

2.1 The applied methodology

Decisive for the design of a business model were the ideas that are pursued in the framework of the PI concept. The elements of PI were mirrored onto the Austrian CEP market and a concept with economic potential was derived. This concept was derived to a business model and a business process using the Hypersystem as a clearing instance in an open system for delivery orders according to defined rules. The determining factor in the rules affects the overriding objective of pooling the volumes and to streamline the distribution streams. Methodically therefore an idealized new system was created, compared to the qualitative rated current situation of the Austrian CEP market. Using a weak point analysis the areas of action were identified in the path towards the idealised system.

2.2 The current situation in small loads distribution systems

One of the hardest themes out of the concept is the topic of standardization. In the current transport industry there are no uniform rules in the field of identification technology, data formats, operational and data interfaces and data interchange technology (WIK-Consult 2015). From an appropriate market position of large, internationally active CEP service provider companies, internal standards are already defined in small areas of cooperation, but these are driven by the market power of competing players (Graf and Kapplmüller 2015). The lack of general market standards represents a major obstacle from the idea of the shared use of assets towards a crosssector transport and service model. For example, a parcel of a CEP service provider cannot be delivered by another one. The barcodes cannot be read and processed by the different systems.

2.3 The lack of standards and pooling systems

There are already initiatives like OPAL (European Open Postal Alliance) focusing on this topic. The SmartBox concept can thematically be oriented along these initiatives and solve the lack of standards by a potential operator as superior authority of transport processes. While the OPAL initiative is looking for the lowest common denominator among the CEP service providers, the concept SmartBox takes over the design of IT interfaces and their standardization. Some existing worldwide standards of the GS1 organization can already be applied wherever possible, that is the statement of the platform GS1 (2015).

Another theme to be stated separately is the need of a container pooling system for reusable delivery boxes (Hakimi/Montreuil/Sarraj/Ballot/Pan 2012). Experiences with established pooling systems point out two determining factors for the SmartBox concept. Firstly, the number of box sizes is limited by the economic need for the lowest amount of fixed assets (Landschützer/Ehrentraut/Jodin 2015). With the rising amount of different box sizes the demand of boxes in the distribution centers increases, because the system has to take care to hold the boxes available for customer shipment. For that reason the fixed assets, in form of boxes, keep too much capital. Therefore, the maximum of four box sizes has been found to be useful in the operative application. In the system SmartBox five box sizes have been developed. Four box sizes (L, M, S, XS) which will be part of a pooling system and one size (XL) which is designed for the needs of luggage and which will be made available on request. The requested pooling system incorporates rather complex processes. It must provide information about the place of need and the corresponding required number of boxes in order to deploy boxes in these places. With intelligent communication technology the information flow can be designed efficiently, furthermore the box itself calls for inspection and maintenance after each transport process. In order to comply with the quality requirements, an empties management is necessary which makes an additional process for value-added transports necessary.

Required communication technology is to proactively initiate transport processes and includes a complete shipment tracking to increase planning accuracy which currently is only available on expensive markets. Appropriate technologies like GSM tracking systems are still very expensive (see http://www.kizytracking.com 2015/09/01). Expensive is also equipping the in the concept participating actors with appropriate technology. It has to be decided who bears the costs of the system which further depends on the operator. From the size of future shipment volumes results the return on investment for participating operators and makes it accordingly attractive. Requested shipment volume can be reached by addressing large retail groups and by considering the needs of the bulk shippers. For these groups and for the CEP service providers a benefit of the system must be recognizable. Here, a potential Hypersystem operator would mediate transfer orders and organize transportation to previously existing CEP networks.

3 Adapting the ideas of PI for a small loads mobility 4.0 system

In the concept SmartBox essential visions of PI were considered to increase the efficiency in the sector of small good deliveries. The modular container supposed to be designed for the Internet of Things is in the form of the SmartBox an essential part of the concept. In addition to the product itself, the standardized and intelligent container holds all relevant information which is necessary for its identification and routing to its destination. Further requirements such as modularity and stack ability are incorporated in the SmartBox development (Montreuil 2009).

The data flow is of similar design as required by the ideas of the PI. Data packets, containing the delivery specific information in tags directly on the box, will be made available by the central Hypersystem and to possible network partners. The system thus ensures interconnectivity among any qualified actors or willing transport partner (Sallez/Pan/Montreuil/Berger/Ballot 2015). This ensures that the concept integrates existing distribution systems, too.

On the one hand relevant data is stored on a smart tag as the box includes local intelligence especially concerning physical access to the content (Montreuil 2011), too. On the other hand, the Hypersystem coordinates the most efficient routing of the SmartBoxes.

3.1 The Business Process

The gap between the ideas of visionary PI and the established CEP distribution systems is currently still big. Standardized containers and linking interfaces between individualized communication systems are yet just as visionary as the resolution of the competition and asset sharing. Designing a joint business processes (the detailed business process can be found in the appendix) was the challenge in overcoming this gap. It could only be realized by aligning the process to the needs and requirements of the end users and by the involvement of existing infrastructure and market situations. A new system has to allow competition as well as to maintain data security.

The essential demands for the process design of a new business model have been achieved by first strictly orientating on customer's needs. These include the reduction of lead-time for online purchases, delivery in desired time windows, the possibility of picking up consignments at points of daily path, the complete shipment tracking in real time, as well as easy and quick handling of the transport organization with easy-to-use software solutions. The focus on customer needs shall make the concept attractive for transport service providers to participate in the concept. The system provides them chances to serve new customers and to utilize bundled capacities as well as to increase own system efficiency. In this case the Hypersystem cares for the organization and management of the data flow to ensure proper incorporation of existing distribution infrastructure for the physical flow of goods.

In addition to the requirements in the areas of B2C the business process is designed in such a way that requirements of the B2B area are met, too. Besides the integration of home delivery and pick-up stations an alternative business process for the micro depots was created. It opens new paths for the involvement of individuals in the delivery process, firstly, to increase the service for the customer and secondly, to increase efficiency in established CEP distribution systems through bundling. In the Last-Last-mile the core delivery process will be replaced or enriched by the new sub-processes of fetching the consignment by the customer. While the core business process contains the SmartTerminal as elements of the drop or pick-up location, the alternative business process is extended by the services of the Last-Last-mile. In both business processes, the aim is to use the pick-up stations for the bundling of amounts and to minimize delivery frequencies. Instead of many delivery runs to one and the same terminal the reduction of transports bears the opportunity to utilize capacities better and thus minimize unprofitable and underutilized delivery routes. The allocation or the algorithms behind the allocation is handled by the Hypersystem. One chosen service provider supplies the SmartTerminal with new deliveries but also collects dropped deliveries in a sustainably designed paired traffic.

The SmartTerminals functions as last mile downstream depots. Nevertheless, the terminal quantities are delivered in bundles. By reaching to the SmartTerminal the recipient receives a message that his delivery arrived and optionally is ready for collection. In case the does not want to pick it up himself or he even does not have the possibility, the receiver can cause a final home delivery within a desired time window. This automatically informs potential local delivery service providers to execute the home deliveries within a predefined service area of SmartTerminals. There is even the possibility for private actors (crowd logistics) to access the SmartTerminals and to be involved in the system.

The Hypersystem serves as IT-instance to collect and maintain the data, to manage the actors of the delivery process and to provide the software intelligence for optimized transport organization. The Hypersystem offers standardized and easy to implement interfaces for the actors in order to minimize the entry barriers for transport service providers. To ensure the coordination mechanism between the stakeholders, it is considered a core responsibility of the operator to place the incoming transfer orders by a distribution scheme to the deliverers. This shall happen, within the meaning of Physical Internet, automatically according to fair and predefined rules as well as order distribution schemes by the system. Each CEP provider may, for example similar to a freight exchange, propose prices for certain relations and thus obtain a transfer order. The basic idea behind this is that the service provider, who can carry the delivery in the most favourable condition and in predefined quality and time, is assigned to a transport. However, this does not automatically imply that only large CEP service providers, who can offer low service costs by high volumes, are able to act in the SmartBox system. Smaller providers may be considered, for example if they already engage in the target areas and thus be able to offer additional transport capacities. Therefore, these logics have to take place in the so called Hypersystem.

In addition the SmartBox operation has to implement and execute the following core tasks:

- Pooling (inventory management and empty management)
- Maintenance / Servicing (for SmartBoxes and SmartTerminals)
- Payment function (for customers and system partners)
- Shipment Tracing & Tracking
- Investment into and operation of the infrastructure (shared assets)

Depending on individual design of operation models, it will be the responsibility of the operator to finance the requested infrastructures. This applies in particular for the SmartBoxes, SmartTerminals and for the central Hypersystem. Also, existing distribution HUB's have to be adapted, e.g. with portals for RFID scanning, cleaning systems, IT and new processes for sorting, bundling and optimized transports.

3.2 The Pooling System

An important key element of the SmartBox system is its function of pooling the containers. As already described above, the restriction to four box sizes is postulated. Core function of the pooling function is to serve the boxes to the places of the demand to ensure the collection from private homes (empties and new deliveries) and to manage a proper empty stock level at terminals. A further function is to ensure proper quality of the box in terms of function and cleanness. The necessity of a pooling feature represents a significant cost driver for the SmartBox system. Principally an empty box transport process would be required per each delivery process additionally. But this must be made as cost effective as possible. Therefore and primarily, the concept attempts to ensure paired traffic for all single deliveries in order to make empty transports needless. Secondly, there would be an option to use empty boxes for waste disposal. The second transport could be to central waste depots then where they clear, clean and may be maintenance it. Otherwise additional transport to SmartBox maintenance cannot be prevented. Here it is important to collect the empties at distribution hubs and to send in the form of FTL to the maintenance instances. The operative role of collection and maintenance for empties represents an important operative part and has to be implemented by provision of responsibilities, remunerations and service fees.

3.3 The Payment Process

In order to achieve operational success regarding the asset sharing cooperation model, a stable payment process with a fair financial clearing function as a key success factor will be essential. Again, a central operator has to take a coordinating role between the contracting and delivering processes. To gain high efficiency it will be necessary that the delivering service providers do not have any responsibility concerning invoicing. And for that reason, an automated processing and clearing of the payment transactions has to be provided by the Hypersystem.

4 The SmartBox Use Cases

Use Cases were created on basis of the established business processes in order to show the performance and represent the benefits of the system in practical examples. The Use Cases describe a possible scope of services of the system and thereby verify the postulated business processes. Furthermore, the creation of the cases ensures consistence in the developed processes.

The main performance of the concept is concentrated on parcel transportation, deliveries of purchases, deliveries in the e-commerce sector, B2B shipments, C2C shipments and as a potential delivery quantity driver the concept of Last-Last-Mile deliveries. The focus when creating the Use Cases was on identifying the final customer, because that is the only way to specifically addressing the needs of the clients during the development of the concept. Just by applying target-group-related forms of services and marketing, the necessary shipping volumes can be achieved.

The Use Cases were analyzed regarding parameters e.g. final customer, shippers and stakeholders, and their characteristics. Concerning the characteristics the transport unit or the functionalities were viewed more closely and the influence factor on SmartBox was evaluated. Therefore, for example in the Use Case of purchases grocery shopping must be considered in the process as well. Alongside another option for purchases exists – the post office box; it represents an additional functionality of the SmartBox and the SmartTerminal. Analyzing these parameters requirements for the operator model can be derived.

The Use Cases were designed sticking to essential framework conditions which are crucial for a future, sustainable and efficient distribution system.

Sustainable solution for the "First- / Last Mile":

This objective is fulfilled in the system SmartBox on several levels. Firstly, the presence of the customer when delivering the consignment is no longer necessary, as the goods are placed in a micro depot or the requested home delivery time is communicated in an internet based portal. In both cases an inefficient second delivery is not necessary. Secondly, the First- and Last-Mile are more sustainable due to the bundling of volumes. There is no more waste of resources because of the utilized transport capacities. A web-based coordination mechanism, organized and managed by an operator, provides the possibility of better matching the capacities of the CEP service providers and to avoid inefficiencies. Therefore, transport orders are managed and organized by a central body which also assigns the carriages according to a certain logic to the forwarders. Based on the example of freight exchange the CEP service providers can utilize empty transportation capacities. Thereby, unprofitable transports are transferred to another CEP service provider who thus can maximize its transport utilization. Therefore, there will be no inefficient transports anymore, as a self-controlled superior mechanism, according to the example of asset sharing, will ascribe the shipments. First- and Last-Mile deliveries are partially unprofitable for freight forwarders. By involving private individuals according to the example of the Austrian service platform “checkrobin”, such short transport relations can be molded more sustainable and cost-efficient. Thereby, a new business model for individuals is created. According to this approach, all available resources on the First- and Last-Mile are utilized efficiently and thus provide a sustainable solution.

Intermodal hubs:

In the system SmartBox main runs may also be executed by train. The requirements are designed that any actor in the transport service industry can participate (e.g. rail, air, road, water, ...). Participation criteria for the concept SmartBox are not related to the modes of transport, it depends on whether the individual freight forwarders implement the requirements for it in their system or not. Thus, the requirements for standardization of data formats from for example established CEP service provider hub's as well as railway container terminal can be established.

Innovative means and modes of transport:

The concept SmartBox involves innovative means of transport as well as different modes of transport. Therefore, in such a system private individuals can participate by collecting the consignment from a micro depot and bringing it to the receiver. Furthermore, in the system SmartBox in the Last-Mile delivery, from the SmartTerminal to the final customer, e-bikes could be integrated. Thus, SmartBox involves innovative technological developments and thereby creates new business models.

Reduction of emissions, energy and resources:

An essential part of the system SmartBox is to reduce the consumption of resources to enable an environmentally sustainable delivery process. The service portfolio of the operator has to be aligned towards an efficient organization of the shipment distribution. Because of the concept of asset sharing quantities can be bundled in the distribution process in order to increase the utilization of the means of transport and the distribution centers. Furthermore the integration of e-mobility in the business process in the fine distribution of consignments in urban areas also reduces emissions. The consumption of traffic areas decreases due to increasing the utilization of individual means of transport on the Last-Mile or the Last-Last-Mile using the system of micro depots.

Likewise, the concept SmartBox is suitable for the shipment of luggage and groceries, which strengthens public local transport. As taking public transportation is often no option because carrying luggage and shopping is not very comfortable.

Guarantee supply of goods and services:

The system SmartBox can provide a 24/7 availability in rural and urban areas. High potential is especially when integrating the steadily growing e-commerce sector in the system SmartBox and then a region-wide supply with goods can be realized. Because of the local and temporal decoupling of the delivery process a high supply quality can be achieved. Via the SmartTerminal the customer gets the opportunity to collect his/her order from key points 24/7. This system is ideally suited for rural areas as well because the SmartTerminals are situated at hot spots of the daily path, for example installed at park-and-ride facilities as hubs for commuters, and so delivery is no longer dependent on a personal presence. In urban areas SmartBox gains in importance because of its function as a micro depot in comparison to traditional pick-up stations. The customer can use the SmartTerminal as a conventional pick-up station which anyhow provides more customer service and efficiency because it can be used by any provider. Furthermore, the customer can wish for a 24/7 delivery service according to his preferred delivery time, as the SmartTerminal also functions as a micro depot and individuals can execute the transportation. The retail sector will be strengthened by the concept as well. The system of the SmartTerminals as pick-up stations can also be used as dispatch stations where for example in shopping malls or streets customers can place their purchases and have them sent home. As mentioned before when using this option the final customers might be more likely to use public transportation.

The Use Cases are subsequently to define the requirements for the operators by comparing the current distribution network of the CEP service providers with the ideas from the business process.

5 Analyzing the gaps between the current situation and the Use Cases

In some areas functionalities and system boundaries in the current distribution system do not yet support the services that are postulated in the Use Cases. Simply the basic idea of sharing assets and the involvement of several market active partners edges to its limits. A fundamental element in the concept SmartBox is the definition of these discrepancies only based on those declarations the boundaries towards a future system of small loads mobility can be dissolved. Moreover, based on the design of the system SmartBox new problems will arise which then be solved in the business model. Both, the discrepancies between the current distribution system and the Use Cases as well as the new occurring problems are gaps on the way to the future small loads mobility – SmartBox.

One of the biggest gaps between the Use Cases and the current system is the overarching coordination mechanism which would be the Hypersystem in the concept SmartBox that is part of the operator model. For potential partners of the CEP sector the participation in the system SmartBox means a horizontal cooperation. Any actor in the system has to decide whether he wants to take part in this cooperation and if, he hast to make sure that it aligns with the company objectives. The basis for this inter-company cooperation is a mechanism which directs the appropriate material, information and financial flows accordingly. It basically depends on the individual strategic company goals whether the actors involve in such a cooperation model or not. Actors whose corporate goals correlate with those of the system will more likely and easily participate than those whose not. Another factor concerning the participation may be a company external one. This could be the interest of gaining more market shares due to the system or it could be legal regulations which make participation mandatory.

Besides the idea of a not yet existing cross-company coordination mechanism, intelligent or so called smart boxes are part of this open system, according to the idea of the PI. The boxes should make the turnover process easier and more efficient and because of their scalability the utilization in transport can be optimized. As well as of the integrated intelligence the box knows its local and functional status and therefore acts as an autonomous agent in the distribution network. It communicates actively with the Hypersystem to initiate its transport. As mentioned here it is necessary to create appropriate interfaces. The standardization of the communication interfaces and the SmartBox is a major topic.

Further gaps exist in regard of the operator model. Here it is especially the legal perspective to be observed. How do contracts have to be designed and how are actors integrated into the distribution system? What responsibilities and functions are divided among the parties? Above all the question regarding the operator and the financing remains – how do appropriate investment concepts or financing variants look like?

6 Defining the core elements

From the analysis of the actual situation, the framework and the gaps from the Use Cases three core elements in the small loads mobility could be derived. SmartBox has identified those and developed potential solutions as follows:

6.1 Standardization

An essential part of the concept is the creation of a coordination mechanism including a system of automatic and standardized data exchange. Standardization is needed as well for data formats and the technical interfaces.

Necessary standard for interface protocols and data connections should be directed by global organizations like GS1 in order to improve value chains. GS1 already defined standards for barcodes, the GTIN (Global Trade Item Number) and EDI (Krölling 2015) and is member of the initiative for an open mail market (OPAL), which is already defining rules for this sector. The specific objective of this inventive is to identify a shipment regardless of the provider who is executing the transport. This task has also to be applied for an open parcel box system. Enabling the identification of each SmartBox an individual identification key will be saved on its smart device (RFID tag).

6.2 SmartBox Container

For the design of the intelligent container detailed construction requirements have been specified. Key request might be highlighted as: compatible to existing loading units like pallets & containers, modular, stackable, reusable, ergonomic, solid and vandalism protective. Electro-mechanical plugs have to be avoided, simply to prevent problems with dirty or wet connectors. The container must offer suitable wireless communication interfaces to support all defined use case scenarios. Only authorized users should be allowed to open the SmartBox, while the authorization must also work in scenarios where no connection to the Hypersystem is available. Energy efficiency plays an important role to ensure long operation periods before recharging is required. Backward compatibility to existing CEP systems must also be taken into account to guarantee a smooth transition from current transportation systems to the new concept.

Based on the defined requirements, the box has been designed and three dimensional models have been constructed and documented (Gerner 2016). Figure 1 shows the SmartBox design concept with a sample display integrated in the side wall of the box. The container consists of a chassis and a lid which holds the locking mechanism and electronics.

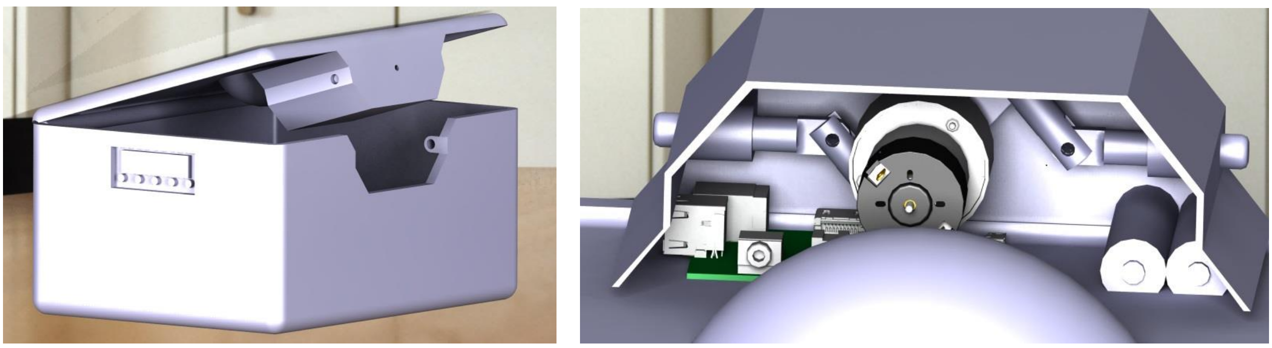

Figure 1: SmartBox Container and its locking mechanism details

Available space next to the locking mechanism in the lid is used for a single-board computer, communication modules and batteries. Intelligent components are consciously grouped in one place to simplify maintenance processes and to avoid extensive cabling between lid and box chassis. Only an electronic paper display with integrated optional buttons and a wireless charging unit are included in the chassis.

The locking mechanism represents a two-point lock based on an Espagnolette. If a rotary motion is applied in the center at the rotary lever, the two locking bolts execute a translational motion. Subsequently the bolts lock or unlock the container by entering or removing from the provided openings in the box chassis, which are intended as counterparts for the bolts. The DC motor must overcome the friction between the materials for a required 60 degree rotation in less than two seconds in an energy efficient way.

The boxes will be available in five different sizes from XS to XL (compare Table 1). Depending on the physical dimension, each box has one central or two separate handles on opposite edges integrated into the lid. These allow for handling the boxes ergonomically and for placing the boxes comfortably into terminals.

Table 1: SmartBox Sizes

Size	Length [mm]	Width [mm]	Height [mm]	Remarks
XL	800	600	400	Largest size – calculation base
L	800	600	200	Half the height of XL
M	400	600	200	Half the length of L
S	400	300	200	Half the width of M
XS	200	300	200	Half the length of S

6.3 SmartTerminal

The SmartTerminal represents a storage interface between logistics providers and the final customer. Following usability requirements of human factors and minimal cube it consists of four drawers where the boxes can be placed on horizontal surfaces. Figure 2 depicts an overview of the terminal on the left hand side and a placement sample with boxes in different sizes on the right hand side. The lowest drawer has twice the height of the top three terminal drawers. As a consequence the XL SmartBox can be placed in the lowest drawer only. Nevertheless smaller boxes can be placed there as well, as shown in the left hand side of Figure 2. In the other three drawers either one L container can be placed in each layer, or two M containers, or four in the size S. As shown in the right hand side, S and M can also be mixed. XS containers can replace SmartBoxes of size S. XS have been introduced later for additional optimization of transport space utilization, but therefore leave unused spaces in terminals (as shown in the left hand side in the SmartTerminal overview and in the top row of the organization sample on the right side). However, the suggested place management assures that all boxes which are equipped with an optional display, present their display on the outside of the drawer. So the displays are never hidden.

Special latches which are adapted from common car trunk or door latches are placed on all terminal drawers. The boxes with dedicated bolts (provided in openings of the box base) can be clicked into these latches to lock the boxes to the terminal. The terminal logic can open the latches for authorized users to release a box.

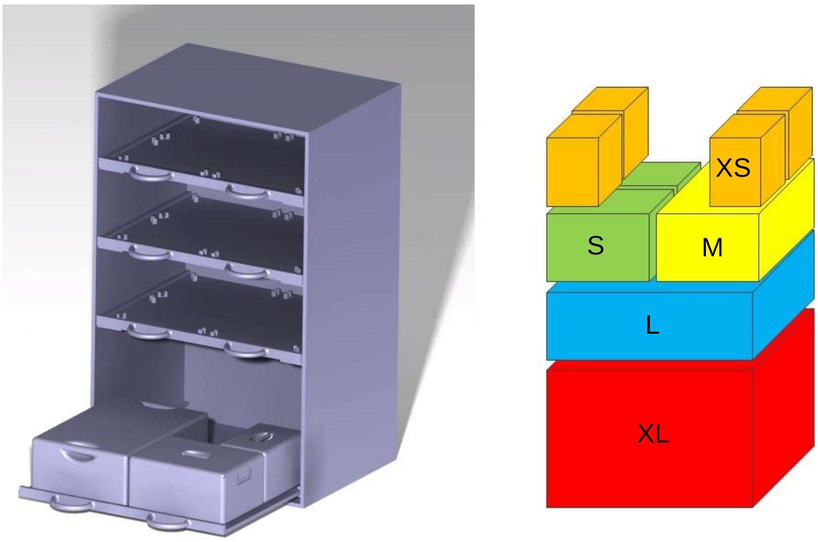

Figure 2: SmartTerminal Overview (left) and Box Organization Samples in drawers (right)

6.4 Information and Communication Technology (ICT)

The main components of the system architecture are the Hypersystem as back end, SmartBoxes, SmartTerminals and handheld devices as user interfaces. Moreover the private PCs of end users and the IT infrastructure of participating CEP service providers participate in the system as well.

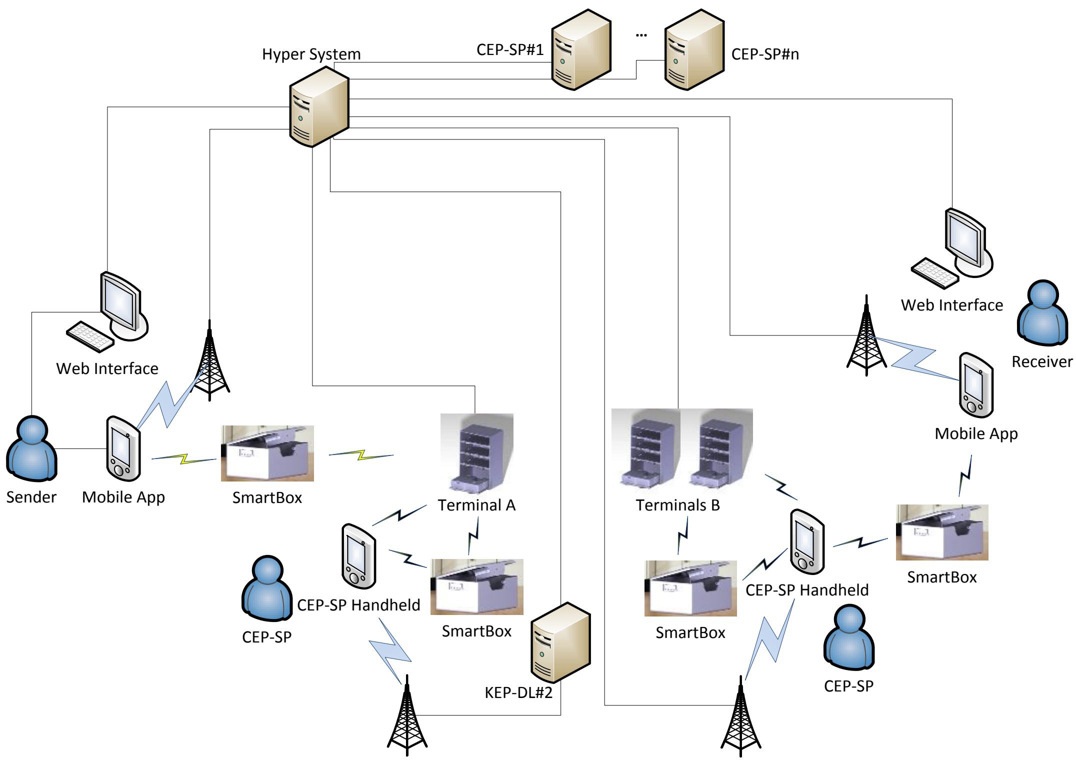

Figure 3: ICT Architecture

The Hypersystem manages the transport of SmartBoxes in a cloud configuration. Each participating CEP service provider maintains standardized data and communication interfaces to the Hypersystem. SmartBoxes communicate with the Hypersystem indirectly with the help of SmartTerminals, handheld devices like smart phones and mobile terminals. As a consequence the SmartBox needs wireless communication interfaces to SmartTerminals and mobile devices. Additionally access points and data relays can be provided in warehouses or trucks to connect boxes with the Hypersystem. Like the smart phones of end users handheld terminals of CEP service providers can either directly communicate with the Hypersystem or use proprietary communication within the CEP company infrastructure for accessing the Hypersystem. End users can communicate with the Hypersystem with personal computers or mobile phones. For the user interaction with terminals and boxes, various different scenarios and technologies can be applied. Based on different Use Cases the required data flow has been defined in UML sequence diagrams. For all scenarios applicable technologies have been reviewed and compared.

Wireless LAN and Bluetooth have been identified as the two most powerful wireless communication technologies to interconnect SmartBoxes and SmartTerminals. As wireless LAN is a widespread technology and perfectly fits the requirements for the interconnection of boxes and terminals, it is the first choice. To reduce the cost of SmartBoxes only one communication technology may be supported in the boxes. Therefore handheld devices would need to support the same technology as the terminals. Especially the Bluetooth 4.0 standard (also called Bluetooth Low Energy or Bluetooth Smart specified by the Bluetooth Special Interest Group, 2010), which aims at the reduction of power consumption, would be an interesting option. While energy efficiency is an advantage of Bluetooth 4.0, wireless LAN supports higher communication ranges. The pairing of handheld devices and SmartBoxes can be done more easily with Bluetooth 4.0 and therefore this technology is slightly favored if only one technology needs to be picked because of economic reasons. Decuir (2014) introduces the basics of Bluetooth Low Energy and gives some first insights into technical details.

Various scenarios and technologies have been analyzed for the user authentication and authorization in order to open a SmartBox. Key proposals are:

- Account-based authentication: Only registered users can log in to the system with their account ID (eg. email address) and password via web interface or the terminal user interfaces.
- Personal Identification Number (PIN): User may receive secret numbers (during the order process, by SMS, per mail/e-Mail, etc.) for their authorization.
- RFID/NFC: Users should also be able to identify themselves by radio-frequency identification (RFID, cp. ISO/IEC 1443, 2008) smart cards or NFC enabled mobile devices (smart phones, handhelds). Both systems could provide a unique ID which can identify a specific user.
- Quick Response (QR) Code: If terminals and or boxes are equipped with cameras or QR-Code readers, users could present printed or displayed QR-Codes in order to open boxes. Users who are not registered in the system could receive printed QR-Codes per mail or the deliverer of a SmartBox could print and leave the code in the post box while he deposits the box in a nearby SmartTerminal.
- Token-based authentication: Trusted, digitally signed tokens are needed to open a box. These tokens are generated in the Hypersystem and need to be passed on to the correct SmartBox.

Finally a mix of different authentications can be used. A security concept with different permission and access levels for different use case has been drafted so far, too. Harant (2016) describes several different Use Cases for sending, receiving and transport processes and lists technical implementation possibilities with its strengths and weaknesses.

7 Further research gaps – business model

The final output of the project SmartBox is an organizational and technical service specification for a PI-based and service provider open distribution system for small loads like parcels or luggage. The aggregation of sub-processes to an overall concept was a crucial project part. Only through a holistic approach an overall concept could be developed by identifying and analyzing gaps and weaknesses of existing services.

Transport network designs of existing CEP-markets are characterized by cost savings and strict internal quality control. Because of the partially high cost of service provider's infrastructure minimal unit costs can only be realized by achieving certain volumes (Haase and Hoppe 2008). Economies of scale will be essential for the SmartBox system, too. Since 95% of shipments within the B2C-market are generated by bulk senders, the integration of the SmartBox system to their sales platforms will be a significant success factor.

Especially the e-commerce sector represents the potential for growth in the CEP market in the coming years. Thereby, customers should already have the possibility to select the option "SmartBox" or their favorite SmartTerminal directly via the web shops. Deliveries to Smart Terminals correspond to the systematics or the trend of Click & Collect. Of course, this only may happen by acceptance of the bulk senders and therefor will be a big success barrier. Agreements should be triggered by the pressure of the customers or by political rules.

Anyway, the coordination of contract awarding from the bulk sender to the system SmartBox has to be done automatically and may not cause additional operational effort. For this reason, the creation of a plug-in for online platforms of bulk senders would be most expedient.

Commercially there will be several pricing models possible. Depending on the individual provider pricing models are currently based on parameters like weight, girth, distance or any combination. In Austria and Germany, compared to other markets, the CEP sector rarely charges distance, because shipments mostly concern the domestic market only (Helmke 2005). For the system SmartBox a specific price model must be defined in such a way, that customers already will be informed about their cost when creating the shipment order. Costing models should be kept as simple as possible for the customers. However, a challenge also is to enforce a fair financial clearing model to freight forwarders. This is not about specific prices for specific cargo but addresses the specific cost parameters of the price calculation.

Corresponding to the topic of controlled provision of information by access restrictions, data protection in general is an essential requirement of the system and unauthorized access has to be avoided. Among other aspects, information, such as billing information or information on location and characteristics of the goods to be shipped are sensitive data.

In order to meet the vision of PI a key requirement regarding ICT will be the implementation of a web-bases platform solution. In the SmartBox context this cloud solution is named "Hypersystem" and should enable smooth interaction of multiple users in real time without creating data inconsistencies.

By using a cloud solution, retrieving and inputting data is possible with different interfaces. For the end customer a smart phone application would be very user-friendly, to generate shipments, to access tracking and tracing information and to unlock a SmartBox from a terminal. However, for the CEP service providers it should be possible, to access the platform via web applications to watch tracking and tracing data and their driver statistics. For the drivers, communication via handhelds or smartphones would be suitable.

This web-based solution can be referred to as Software as a Service (SaaS). Therefore, users can use the software without having to have software installed on their own computers. The concept of a software platform also requires that appropriate memory and computing capacity is being created, for example, to guarantee adequate response time (Weiner/Renner/Kett 2010).

The explained services shall be operationalized through an algorithm to allocate transport orders automatically and to make it possible for customers to access shipment data and statistics. The core algorithm is still an open research area. Shareholder concepts and access to shipment volumes are mutually pendent.

8 Outlook and next steps

The next step after the conception of the hardware components (SmartBox and SmartTerminal) and definition of the service portfolio is the development of appropriate operator models. The barriers towards small loads mobility 4.0 have already been described with further research gaps in paragraph 5. While creating detailed processes for the business models, these research gaps will be stated and adapted more precisely under consideration of the present market conditions.

Moreover, workshops with established players on the CEP-market shall be held, to enable the participation of these players in the new system for small loads mobility despite their competing business models. New business models shall be defined, to make it possible for CEP-service providers to manage the challenges of the future system of distribution of goods minding the concepts of asset sharing and open networks. Shareholder models, financial clearing and standardization models as well as the implementation of intelligent modular containers are elements of the new developed operator and business models.

9 Conclusion

The concept of SmartBox describes revolutionizing services to approach the PI-based small loads mobility in future. It designs and defines new business processes and Use Cases, taking into account actual market developments. By analyzing the gaps between current distribution systems and future Use Cases the needs for action were identified.

The lack of standardization in the fields of unit loads, infrastructure as well as communication/ information technology are major obstacles for future cross-company-cooperation.

Therefor data must be exchanged via an open platform – the Hypersystem - between the actors involved in distribution and transport. Relevant information has to be made available to the customer for tracking and tracing, too. Thus, standardization removes barriers in cooperation models and allows the players in the market to adjust their activity towards customer development. According to certain regulations partners within the system must be able to read information relevant to them. Referring to this GS1 offers already a potential solution to gather standardized information about the goods, unit loads and infrastructure to make it available to the system via automated interfaces.

SmartBoxes and SmartTerminals are core elements concerning the infrastructure of sustainable reusable container in an open, shared and standardized delivery system for small goods. Through the intelligent SmartBox and the integrative Hypersystem it is possible to consolidate volumes and to increase utilization within the distribution system. Offering paired transports as well as the Smart Terminal creates additional customer benefits and enables the integration of private players for the distribution in the Last-Last-Mile.

A suitable communication technology represents the cornerstone of the system and enables an automated data flow of standardized data. The interfaces between the Hypersystem and actors are designed under consideration of the latest developments in ICT. The use of reliable technologies raises the availability of the system for the customer.

After identifying the core elements and feature further research gaps arise which are the basis for future projects. Drafting a business models for the Austrian market the SmartBox concept manages to implement PI ideas and makes practical challenges visible. Further research will give quick answers to pave the way towards PI.

10 References

Bluetooth Special Interest Group SIG (2010) Bluetooth Specification Version 4.0

Bogdanski R. (2014). *Nachhaltige Stadtlogistik durch Kurier-, Express-, Paketdienste*. Berlin: Bundesverband Paket & Express Logistik BIEK.

Decuir J. (2014): *Introducing Bluetooth Smart - Part 1: A look at both classic and new technologies*. IEEE Consumer Electronics Magazine, Volume 3, Issue 1, pp. 12-18, January 2014

e.V., B. d.-E.-P.-D. (2015). Open Postal Alliance. 2015/09/01 sourced from: http://www.open-postal-alliance.de/

Gerner S. (2016): *SmartBox*. BSc thesis, Automation Engineering, Upper Austria University of Applied Sciences, Wels, Austria

Graf H.-C., Kapplmüller H. (2015):*”smartBOX” – A business concept towards the Physical Internet*. In: Businewss Logistics in Modern Managment. Proceedings of The 15th International Scientific Conference (2015), pp 253-262

Harant M.P. (2016): *Automation Concepts for Intelligent Transport Containers*. BSc thesis, Automation Engineering, Upper Austria University of Applied Sciences, Wels, Austria

http://magazin.gs1-germany.de/home/single/news/gleicher-zugang-fuer-alle/ [2015/05/08].

Haase K., Hoppe M. (2008): *Transportnetzgestaltung für Paketdienstleister*. In: Zeitschrift für Betriebswirtschaft, 78, 9/2008, S. 857ff.

Hakimi D., Montreuil B., Sarraj R., Ballot E., Pan S. (2012): *Simulating a Physical Internet enabled mobility Web: The case of mass distribution in France*, 9th International Conference of Modeling, Optimization and Simulation – MOSIM ‘12

Helmke C. (2005): *Der Markt für Paket- und Expressdienste. Eine Studie zu Kundenzufriedenheit und Kundenbindung im Markt für Paket- und Expressdeinste*, Kassel, Disseratation

ISO/IEC1443-1 (2008): Identification cards, Contactless integrated circuit cards, Proximity cards, Part 1: Physical characteristics, International Organization for Standardization Std.

Kizy tracking. (2015). kizy global tracking. 2015/09/01 sourced from: http://www.kizytracking.com/de/

Krölling A. (2015): GS1 Austria GmbH – Das Unternehmen. 2015/05/08 sourced from: http://www.gs1.at/wir-ueber-uns/das-unternehmen

Landschützer C., Ehrentraut F., Jodin D. (2015): *Containers for the Physical Internet: requirements and engineering design related to FMCG logistics*. In: Logistic Research (2015). DOI 10.1007/s12159-015-0126-3

Montreuil B. (2011): *Towards a Physical Internet: Meeting the Global Logistics Sustainability Grand Challenge*, Logistics Research, v3, no2-3, 71-87.

Montreuil B. (2013): *Physical Internet Manifesto*, v1.10, (Original v1.0, 2009), www.physicalinternetinitiative.org, 2014/02/20.

Sallez Y., Pan S., Montreuil B., Berger T., Ballot E. (2015): *On the activeness of intelligent Physical Internet containers*. Computers in Industry (2016)

Schnedlitz, Lienbacher, Waldegg-Lindl B., Waldegg-Lindl M. (2013): *Last Mile: Die letzten – und teuersten – Meter zum Kunden im B2C E-Commerce*. In: Handel in Theorie und Praxis; issued by: Crockford/Ritschel/Schmieder; Wiesbaden, Springer Gabler

Weiner N., Renner T., Kett H. (2010): *Geschäftsmodelle im "Internet der Dienste". Aktueller Stand in Forschung und Praxis* (THESUS), Stuttgart

WIK-Consult GmbH (2015): *Einfluss von Digitalisierung und Standardisierung auf Post- und Citylogistik*. 2016/04/29 Sourced from: http://bdkep.de/kep-studie-und-dokumente

11 Appendix

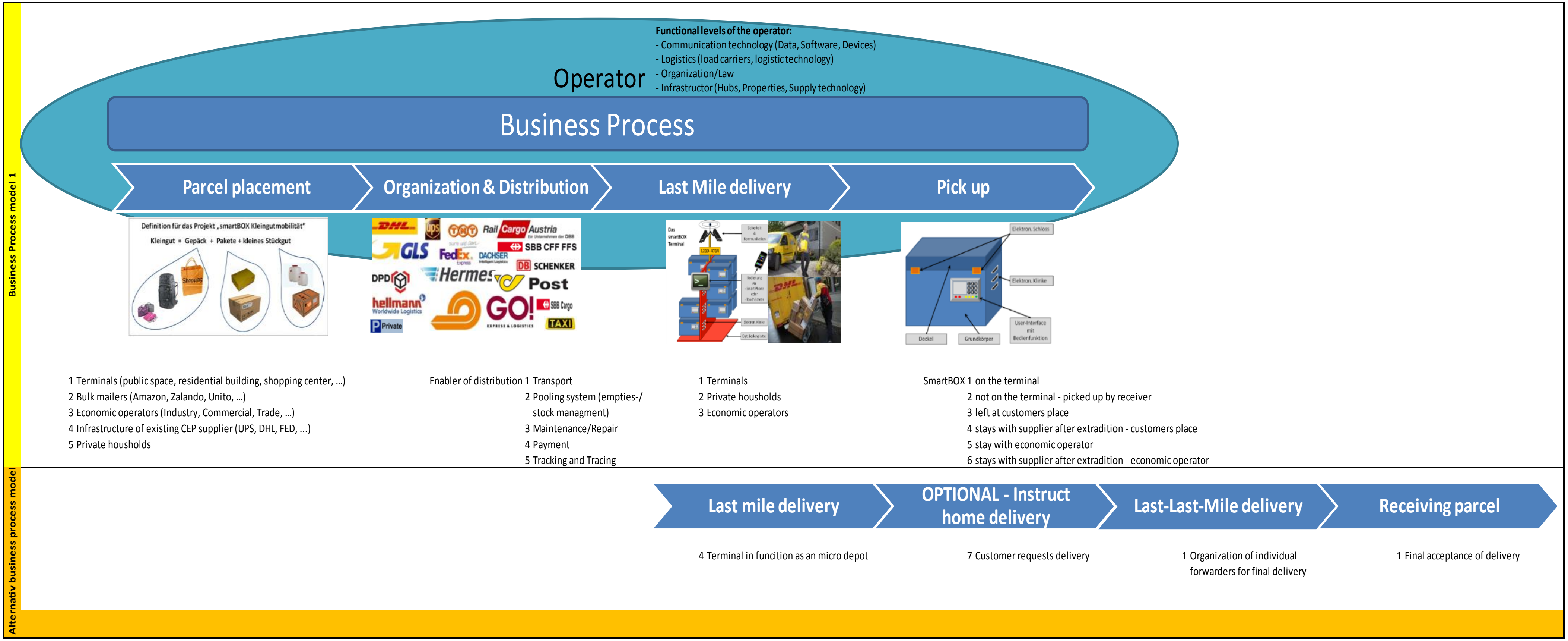

Figure 4: Detailed SmartBox business process structure